Supply chain in the C-suite

Supply chain in the C-suite: the effect of chief supply chain officers on incidence of product recalls

Maximilian Körber and Diogo Cotta
School of Business and Economics, Maastricht University, Maastricht, The Netherlands

Abstract

Purpose – This study aims to investigate the extent to which the presence of chief supply chain officers (CSCOs) in top management teams (TMTs) helps firms to reduce the incidence of product recalls.

Design/methodology/approach – The authors identified all recalls for the period 2010–2017 issued by publicly held firms regulated by the US Consumer Product Safety Commission. These data were subsequently combined with information on TMT composition from BoardEx and financial performance data from Compustat to create a unique data set.

Findings – The study identified a significant and negative association between CSCO presence and incidence of product recalls. The evidence also supports the conjecture that this association is stronger in larger firms, indicating that CSCOs are especially effective when operating within more complex supply chains.

Practical implications – The findings provide important insights into quality management in contemporary supply chains and indicate that assigning specific responsibility for supply chain management to a TMT member improves product reliability.

Originality/value – These findings contribute to the growing literature on the underlying causes of a product recall by identifying corporate governance antecedents of external quality failures of this kind.

Keywords Quality management, Senior management, SCM competency, SCM performance, Product recall, Chief supply chain officer (CSCO), Supply chain quality management, Econometric modelling

Paper type Research paper

1. Introduction

Why do some firms issue more product recalls than others? In the past decade, there has been an upsurge in the number of recalls across various product categories and industry types (Cowley, 2016; Eshkenazi, 2016; Lucas, 2018; Ducharme, 2019). Moreover, posing significant financial and reputational risks for firms, these defective products constitute a serious health and safety hazard for consumers. As one extreme example, toy manufacturer Mattel recalled 4.7 million units of an infant sleeper device that failed to prevent babies from rolling over – a design flaw that is believed to have caused more than 30 deaths since 2009 due to airflow blockage (Frankel, 2019). While most recalls are not a consequence of such tragic outcomes, cases involving fatalities such as Mattel's sleepers, Takata's airbags (Chillingworth, 2020), Toyota's accelerators (Douglas and Fletcher, 2014) or Ikea's dressers (Kerley et al., 2016) have heightened interest amongst operations and supply chain management scholars and society at large in the drivers of product recalls. Not surprisingly, then, an increasing number of recent studies have investigated the underlying causes (Steven et al., 2014; Wowak et al., 2015; Hall and Johnson-Hall, 2017; Shah et al., 2017; Ball et al., 2018).

Studies of the drivers of product recalls tend to focus on supply chain characteristics commonly associated with such external quality failures (Dolci et al., 2017). In this regard, there is evidence that firms with large product portfolios (Shah et al., 2017) and those lacking a manufacturing focus (Thirumalai and Sinha, 2011) generate a higher volume of recalls. These findings clarify the relationship between the incidence of systematic external quality failures and strategic operational decisions about variety reduction (Shah et al., 2017), the extent of outsourcing (Steven et al., 2014) or implementation of quality management standards (Chiarini, 2015).

Interestingly, despite evidence that firms increasingly recognise the importance of both strategic corporate governance and operational decisions in reducing the incidence

of product recalls (Kashmiri and Brower, 2016; Thalbauer, 2016; Ziobro, 2020), the relationship between corporate governance and product recalls remains poorly understood (Wowak and Boone, 2015). For example, while the quality management literature has consistently emphasised the importance of top management support in ensuring quality excellence (Deming, 1986; Saraph *et al.*, 1989; Anderson *et al.*, 1994; Flynn *et al.*, 1994; Ahire and O'Shaughnessy, 1998; Rungtusanatham *et al.*, 1998; Kaynak, 2003; Lin *et al.*, 2005; Kaynak and Hartley, 2008; Lin *et al.*, 2013; Su *et al.*, 2014), very few studies have examined how top management team (TMT) composition impacts incidence of recalls. This is an important issue because top executives are ultimately responsible for creating, communicating, implementing and monitoring an organisation-wide vision for quality management and performance. To that extent, analysis of TMT composition may help to explain why some firms generate more recalls than others (Kashmiri and Brower, 2016). Additionally, practical guidance regarding effective governance structures is likely to help such firms to ensure that high-quality performance is prioritised throughout the organisation and its supply chain.

The present study investigates the relationship between product recalls and strategic corporate governance decisions by examining the influence of TMT composition on the incidence of recalls, focusing on the presence and role of chief supply chain officers (CSCOs) in TMTs. Our main contention is that CSCOs with the necessary authority and resources to oversee supply chain-wide quality management activities (Kador, 2012) can bring a cross-organisational perspective that facilitates TMT understanding of the trade-offs between quality excellence and other strategic performance objectives (Wheelwright, 1984; Roh *et al.*, 2016). Specifically, the study investigates whether public firms with a CSCO in the TMT generated fewer recalls during the period 2010-2017 by matching US Consumer Product Safety Commission (CPSC) data with TMT composition data from BoardEx and financial data from Compustat.

This study makes a number of contributions to research and practice. Firstly, it adds to the emerging literature on antecedents of recalls by examining the relationship between recall occurrence and the strategic corporate governance decision to include a CSCO in the TMT. In so doing, the study responds to the call for more research on nonoperational antecedents of recalls (Wowak and Boone, 2015) and clarifies the relationship between corporate governance and quality management. Secondly, this is the first study to link CSCO presence to nonfinancial dimensions of firm performance (Wagner and Kemmerling, 2014; Hendricks *et al.*, 2015; Roh *et al.*, 2016). Finally, the study explores whether quality performance is affected by appointing insiders rather than outsiders as CSCOs.

2. Literature review and hypotheses

2.1 Product recalls
A product recall is the repair, replacement or removal of a product already in the consumer's possession (CPSC, 2012; Ni

et al., 2014). Product recalls typically occur when a batch of products is deemed defective and/or dangerous. As manifestations of undetected quality failures (Chao *et al.*, 2009), recalls are a consequence of poor quality assurance in supply chain processes.

There is widespread evidence of a steady increase in the incidence of recalls over the past decade (Cowley, 2016; Eshkenazi, 2016; Lucas, 2018; Ducharme, 2019) across multiple product categories and industrial sectors that include automotive (Shah *et al.*, 2017); pharmaceutical (Ball *et al.*, 2018); medical devices (Thirumalai and Sinha, 2011); toys (Hora *et al.*, 2011); and food products (Hall and Johnson-Hall, 2017). In light of the costly and potentially dangerous repercussions for consumers and firms alike, this phenomenon warrants further investigation.

2.2 Consequences of product recalls
Responding to the need for a more comprehensive understanding of the factors associated with product recalls, operations and supply chain management scholars have examined the negative effects on a wide range of firm performance metrics. Existing evidence suggests that the incidence of product recalls is negatively associated with brand equity (Dawar and Pillutla, 2000); marketing effectiveness (Van Heerde *et al.*, 2007); customer demand (Grafton *et al.*, 1981; Reilly and Hoffer, 1983); market share (Rhee and Haunschild, 2006); and shareholder wealth (Jarrell and Peltzman, 1985; Chen *et al.*, 2009; Thirumalai and Sinha, 2011; Ni *et al.*, 2014). These damaging consequences have been verified across a wide range of industries and product types (Chen *et al.*, 2009).

Even more importantly, perhaps, product recalls protect consumers by removing dangerous products from the market. To the extent that firms and/or regulatory agencies become aware of actual or potential product hazards, a recall prevents any or further harm to consumers. For example, when Target recently decided to recall 500,000 toy cars because of a choking hazard, no injuries had yet been reported (Morris, 2019); if that recall had not been issued, the threat posed by the product's detachable wheels might have resulted in serious incidents.

2.3 Antecedents of product recalls
The significant negative consequences of a product recall for firms and the associated hazards for society have prompted increased interest in causal drivers and related factors (Wowak and Boone, 2015). A number of studies exploring elements of the operating environment associated with an increased incidence of recalls have revealed a complicated predicament for firms. If operational complexities arising from product variety and lack of manufacturing focus lead to more recalls (Thirumalai and Sinha, 2011; Shah *et al.*, 2017), extending supply chains by outsourcing order fulfilment activities to specialists is unlikely to alleviate the problem (Steven *et al.*, 2014). For example, outsourcing to offshore specialists reduces visibility as a consequence of geographical separation (Haleem *et al.*, 2018). The situation is all the more challenging in more competitive markets,

where firms are known to issue more recalls (Ball *et al.*, 2018).

More positively, there is also some evidence that the incidence of product recalls can be reduced by making appropriate strategic decisions – for example, implementing comprehensive supplier selection and auditing practices (Das, 2011; Tse and Tan, 2012) or developing close relationships with critical suppliers (Chao *et al.*, 2009; Soares *et al.*, 2017). In terms of internal operations, firms can improve the quality of their product portfolio and so reduce the incidence of recalls by implementing quality management standards (Chiarini, 2015; Phan *et al.*, 2019) or developing quality assurance and control capabilities (Kiani *et al.*, 2009).

Amongst the few studies investigating corporate governance-related antecedents of recalls, Bromiley and Marcus (1989) found that shareholder wealth changes do not incentivise executives to make product safety decisions that reduce product recalls. More recently, Wowak *et al.* (2015) reported that the use of stock option schemes to compensate chief executive officers (CEOs) increased the probability and frequency of recalls. These findings suggest that executives may deliberately reduce the allocation of resources to quality assurance in an effort to boost stock market performance in the short term. At the same time, it seems clear that executive decisions at the TMT level affect the incidence of product recalls, consumer compensation measures (Liu *et al.*, 2016) and the organisation's general approach to crisis management (Greening and Johnson, 1997).

However, to the best of our knowledge, only Kashmiri and Brower (2016) have directly investigated the relationship between TMT composition and incidence of product recalls. They found that the presence of a Chief Marketing Officer at the TMT level reduced the likelihood of product recalls. This indicates that investigating TMT composition can offer relevant insights into the phenomenon of product recalls, which is aligned with the tenets of upper echelons theory. Upper echelons theory posits that studying TMT members and TMT

composition offers important insights on the nature of firm activities and performance (Hambrick and Mason, 1984; Hambrick, 2007; Finkelstein *et al.*, 2009). Although much of the literature is focused on the CEO role (Menz, 2012; Bromiley and Rau, 2016 for recent reviews), scholars have investigated the impact of other individual executives such as chief financial officers (Mian, 2001), chief technology officers (Medcof, 2008), chief information officers (Grover *et al.*, 1993), chief marketing officers (Nath and Mahajan, 2008), chief strategy officers (Menz and Scheef, 2014), chief sustainability officers (Strand, 2013) and chief operating officers (Hambrick and Cannella, 2004). Recently, scholars have begun examining the appointment drivers and performance benefits of having CSCOs in the TMT (Wagner and Kemmerling, 2014; Hendricks *et al.*, 2015; Roh *et al.*, 2016; Kumar and Paraskevas, 2018). The next section discusses the inclusion of CSCOs in the TMT and the expected impact on the incidence of product recalls.

2.4 Rise of the chief supply chain officer

The rise of CSCOs marks a direct response to the challenges of managing geographically dispersed and outsourced 21st century supply chains (Durach and Wiengarten, 2017). In the year 2000, only one CSCO had been appointed in an S&P 1500 firm; by 2012, that number had increased at an average rate of 8 per year (Roh *et al.*, 2016). Wagner and Kemmerling (2014) reported a similar trend in Dow Jones listed firms, where CSCOs doubled in number between 2004 and 2009. More recent BoardEx data corroborate this trend, showing a significant increase in CSCO appointments in the second decade of this century (Figure 1). As a consequence, operations and supply chain management researchers have become increasingly interested in the drivers and performance benefits of appointing a CSCO to the TMT (Wagner and Kemmerling, 2014; Hendricks *et al.*, 2015; Roh *et al.*, 2016; Kumar and Paraskevas, 2018).

Figure 1 Cumulative CSCO positions of all BoardEx-tracked firms by year (2000 to 2017)
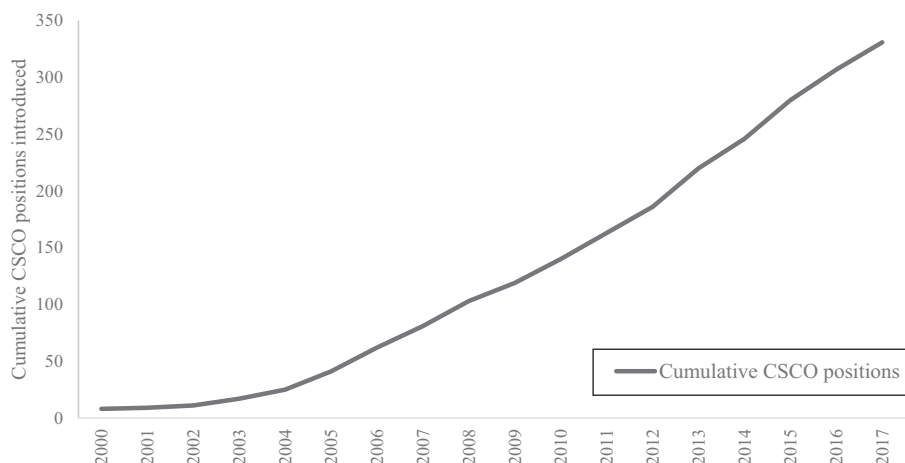
Note: The identification of the CSCOs follows the same query as described in the independent variables section
Source: BoardEx

CSCOs are "TMT-level executives who are explicitly responsible for enterprise-wide supply chain management activities" (Roh *et al.*, 2016, p. 50). These activities include overseeing sourcing strategies, ensuring intra- and inter-firm integration, managing supply chain risks, building and maintaining partnerships with key customers and suppliers and supervising production and logistics operations. CSCOs are also responsible for developing operational capabilities that support the firm's strategic goals (Demeester *et al.*, 2014). Anecdotal evidence suggests that CSCOs enjoy a great deal of decision-making influence in TMTs (Roh *et al.*, 2016), even ultimately reaching CEO positions as in the cases of Tim Cook at Apple and Pier Luigi Sigismondi at Unilever. The scientific literature, however, reports mixed findings regarding the performance effects of having a CSCO in the TMT. While announcing the appointment of supply chain executives is rewarded by the stock market (Hendricks *et al.*, 2015), there is no evidence that CSCO presence on the TMT is directly linked to return on assets (Roh *et al.*, 2016) or operating profits (Wagner and Kemmerling, 2014); in other words, the positive market reaction reflects an expectation that is not supported by yearly financial metrics. This inconsistency may be explained by the limitations of yearly financial indicators that may fail to fully capture the effects of strategic supply chain decisions (Ellinger *et al.*, 2011) – especially strategic decisions that affect infrequent operational outcomes, driven by factors that are resistant to change and have long-lasting financial impacts (Wowak *et al.*, 2013). To augment existing research, we tested this conjecture by investigating the relationship between the presence of supply chain executives in the C-suite and recall incidence as a metric of operational excellence.

2.5 Presence of chief supply chain officers in the top management team and incidence of product recalls

Recalls are a consequence of failure to prevent, detect and adequately address quality problems before the product reaches the consumer, indicating ineffective quality management in the supply chain. The quality management literature identifies top management support as a critical factor in effective quality management, where the TMT accepts ultimate responsibility for quality-related issues, engages in strategic quality planning, participates actively in quality improvement initiatives and acknowledges trade-offs amongst cost, delivery and quality (Deming, 1986; Saraph *et al.*, 1989; Anderson *et al.*, 1994; Flynn *et al.*, 1994; Ahire and O'Shaughnessy, 1998; Rungtusanatham *et al.*, 1998; Kaynak, 2003; Lin *et al.*, 2005; Kaynak and Hartley, 2008; Lin *et al.*, 2013; Shee *et al.*, 2018). In this view, the TMT is responsible for ensuring that the conditions for high-quality performance are prioritised throughout the organisation and its supply chain.

In accepting ultimate responsibility for quality management and performance, the TMT must supervise and integrate all flows of materials, information and funds that influence product conformance and reliability (Foster, 2008; Foster *et al.*, 2011; Sharif and Irani, 2012; Soares *et al.*, 2017; Hong *et al.*, 2019). The present study tested the central proposition that the presence of a CSCO on the TMT can help to ensure that these flows are more effectively supervised and integrated, so reducing the incidence of quality failures that generate the need to recall a batch of products. There are three fundamental

grounds for this conjecture. Firstly, TMTs that include a CSCO are likely to be more effective in monitoring the quality of materials flowing through the supply chain. This prevents quality failures from reaching the market by ensuring the detection of defects in purchased inputs and in outputs manufactured or generated by delivery logistics. Additionally, effective quality assurance procedures such as process improvement initiatives, inbound and outbound quality controls and product testing are more likely to be in place because the CSCO enhances TMT awareness of inadequate quality assurance procedures and ability to manage associated risks (Flöthmann and Hoberg, 2017; Soares *et al.*, 2017).

Secondly, the presence of a CSCO in the TMT is likely to enhance the management of quality-related information flows. High-quality performance depends in part on an ability to gather, analyse and share information about product and process quality, both across functions and with supply chain partners (Nair, 2006; Kaynak and Hartley, 2008; Shee *et al.*, 2018; Hong *et al.*, 2019). As TMT members, CSCOs are responsible for monitoring the timeliness and accuracy of quality-related information exchange across organisational functions. Timely and accurate cross-functional information exchange facilitates the identification of quality problems, the cross-functional investigation of root causes and the development of effective solutions (Hackman and Wageman, 1995; Zu *et al.*, 2008; Wiengarten *et al.*, 2019) to intercept serious defects before the product reaches the consumer. Having a CSCO in the TMT also centralises the assessment of this information exchange and integration practices and facilitates the implementation of organisation-wide improvements when required.

By centralising the assessment of quality-related information exchange and integration with materials suppliers and service providers, including measurement of supplier quality performance and feedback for improvement (Krause, 1997; Huo *et al.*, 2016), a CSCO can ensure early detection and adequate resolution of quality issues (Xu, 2011; Prajogo and Olhager, 2012; Kumar *et al.*, 2018). CSCOs can also help TMTs to assess the effectiveness and efficiency of quality-related information exchange and integration with component suppliers and logistics service providers. In this regard, CSCO's presence is likely to influence strategic decision-making and actions to improve quality-related communication with supply chain partners.

Thirdly, including a CSCO in the TMT is likely to enhance management of the flow of funds for quality-related expenditures (Ahire and O'Shaughnessy, 1998; Hsu *et al.*, 2009; Sandberg and Abrahamsson, 2010). Product recalls may reflect the inadequate allocation of financial resources to quality assurance in sourcing, design, manufacturing or logistic processes (Feigenbaum, 1983; Juran, 1999) and TMTs that include a CSCO are more likely to allocate appropriate funds to quality assurance procedures and quality management initiatives such as Six-Sigma, ISO 9000 or Total Quality Management. CSCOs can also argue for investment in the latest information technology (IT) tools to ensure that quality-related information is integrated across functions. Additionally, as competitive pressures increasingly require TMTs to improve margins and profitability, CSCOs can guide the quest for efficiency without undue risk to quality performance.

As suppliers are usually at fault for recall-inducing defects (Foster, 2008; Steven *et al.*, 2014: Yu and Huo, 2018), CSCOs can also play a critical role in ensuring that supplier selection, auditing and development initiatives are adequately funded. Earlier studies have reported that maintenance of close buyer-supplier relationships is associated with better quality outcomes (Larson, 1994; Forker, 1997; Fynes *et al.*, 2005; Lai *et al.*, 2005; Terpend *et al.*, 2008; Noshad and Awasthi, 2015; Marodin *et al.*, 2017) and building and managing strategic relationships with critical partners is seen as a fundamental element of effective supply chain leadership (Wagner and Kemmerling, 2014; Hendricks *et al.*, 2015; Roh *et al.*, 2016; Flöthmann and Hoberg, 2017). Including a CSCO in the TMT foregrounds the strategic importance of partner relationship management, making it more likely that appropriate funds will be allocated to the long-term management of those relationships.

Based on the above arguments, we hypothesised that the presence of CSCOs in TMTs would influence strategic decision-making for high-quality performance. To capture the relationship between product recalls and the presence of supply chain executives in the TMT, the following hypothesis was formulated:

H1. Firms that include a CSCO in the TMT exhibit a lower incidence of product recalls.

2.6 The moderating effect of firm size

At the same time, it seems unlikely that the presence of a CSCO in the TMT will provide the same protection against major quality failures in every firm. Previous studies have shown that TMT effectiveness is contingent on several characteristics of the firm, amongst which firm size is one of the most consequential and widely investigated (Dalton *et al.*, 1999; Forbes and Milliken, 1999; Kiel and Nicholson, 2003; Boyd *et al.*, 2011). In the present context, we expect the firm size to negatively moderate the hypothesised negative relationship between CSCO TMT presence and incidence of product recalls.

In Section 2.5, it was argued that CSCOs can enhance quality outcomes by supervising flows of materials, information and funds in both internal and external supply chains and by guiding strategic decision-making regarding investment in quality improvements. These effects are likely to be stronger in large firms, which are more centrally positioned in dense supply chain networks (Bode and Wagner, 2015; Lu and Shang, 2017). Additionally, larger firms tend to have more departments and more hierarchical layers, with greater functional specialisation (Daft, 1995; Hendricks and Singhal, 2001; Damanpour, 2010). Greater interdependence amongst external and internal members of the supply chain increases the importance and impact of the CSCO's role in supervising and integrating quality of materials, information exchange and allocation of funds. Conversely, less hierarchical smaller firms with less dense supply networks tend to rely more on informal communication channels (Jayaram *et al.*, 2010), making the CSCO's centralising role less necessary and, perhaps, less effective.

Secondly, the impact of CSCOs on quality outcomes is likely to be stronger in large firms, which typically have more resources at their disposal (Boyer *et al.*, 1996; Golicic and Smith, 2013).

This, in turn, means that CSCOs will have more opportunities to configure and reconfigure those resources to reduce the incidence of external quality failures through quality assurance initiatives. Firms with more resources also tend to have more power over their supply chain partners (Koufteros *et al.*, 2007), enabling CSCOs to deploy their expertise, experience and contacts to create collaborative relationships (Zsidisin and Ellram, 2003) that ensure timely and accurate exchange of quality-related information and make it more likely that inbound and outbound flows of materials will be defect-free (Cao and Zhang, 2011).

For these reasons, it was hypothesised that the negative relationship between CSCO presence in the TMT and incidence of product recalls would be stronger in larger firms:

H2. CSCO presence in the TMT reduces recall incidence more in larger firms than in smaller firms.

3. Methodology

3.1 Research context

The consumer products sector, which is regulated by the US CPSC, was chosen as the study setting for three reasons. Firstly, the CPSC recall database is amongst the most comprehensive available. Firms regulated by the CPSC are subject to "uniform safety standards for consumer products" (Ni *et al.*, 2014, p. 310) as defined by the 1972 Consumer Product Safety Act (CPSA) and the 2008 Consumer Product Safety Improvement Act (CPSIA). When issuing a recall, firms must follow a predefined reporting structure (CPSC, 2012), including identification and description of the product, model and model number, name and address of the manufacturer and/or importer, nature and extent of the possible defect and nature of the potential injury or risk. The standardised reporting practices mandated by the CPSA and CPSIA guard against spurious variations in quality and safety requirements.

Secondly, while CSCO inclusion in TMTs remains generally rare (Roh *et al.*, 2016), it is more common in the consumer products sector (Wagner and Kemmerling, 2014) and it is, therefore, appropriate to study the relationship between product recalls and CSCO TMT presence in this setting. Finally, product recalls are a significant issue in this sector because they can incur severe direct and indirect costs for firms and consumers alike (Gibson, 1995; Kumar and Schmitz, 2011).

3.2 Sample description and data sources

To test the above hypotheses, data were collected from three sources: the CPSC recall database, BoardEx and Compustat. Recall-related data were collected from the CPSC database; the CPSC has jurisdiction over products that include electronics, clothing and accessories, bicycles, furniture, toys, infant and children's products, household products, outdoor products and sports and recreation products (CPSC, 2018). Ni *et al.* (2014) have detailed the CPSC process, including pre- and post-recall announcements, agencies' scope and examples of recall announcements. For present purposes, every firm that issued at least one recall between 2010 and 2017 was identified and this information was used to retrieve TMT composition data for each of those firms from BoardEx, which provides

complete information about directors and executives of publicly listed firms worldwide. Financial and firmographic data for each firm were collected from the Compustat database; data on North American firms were gathered from the North America–Daily Fundamentals Annual data set and data on non-American firms were acquired from the Global–Daily Fundamentals Annual data set. These data were combined to create a unique panel data set containing 885 firm-year observations for 126 firms.

3.3 Dependent variable

The dependent variable was the number of recalls issued by a given firm for a given year, which is the operational definition commonly used in the recent recall literature (Steven *et al.*, 2014; Wowak *et al.*, 2015; Shah *et al.*, 2017; Hall and Johnson-Hall, 2017; Ball *et al.*, 2018). In the present sample, values for this variable ranged from 0 to 14.

3.4 Independent variables

CSCO presence (CSCO). The main independent variable was *CSCO presence* in the TMT in a given year. As this is a relatively recent title and position, uniform usage of the term CSCO is unlikely (Wagner and Kemmerling, 2014; Roh *et al.*, 2016). For that reason, the present study adopted Roh *et al.'s* (2016) approach, using the following BoardEx data to identify CSCO presence in the TMT:

- job title "chief supply chain officer" or "CSCO"; and
- job title containing the term "supply chain" accompanied by "corporate", "chief", "executive vice president", "executive VP", "group director", "group vice president" or "group VP".

On that basis, the recall announcing firm was included if it had a CSCO in place for at least six months of a given year. This criterion was adopted for two reasons. Firstly, the time from discovery to recall announcement (which is very specific but often unobservable) may often exceed half a year (Ni and Huang, 2017); for example, if a quality issue occurs in February and the associated recall is issued in September, a CSCO appointed in July may exert only a tenuous influence on the complex chain of underlying causes. Secondly, as decisions made by a newly appointed CSCO may not take effect for some time, the appointment itself is of less interest than its effects. On that basis, *CSCO presence* was measured as a dichotomous outcome as follows. The variable was coded "1" if a CSCO was present in the TMT for at least six months in a given firm-year and as "0" if no CSCO was present in the TMT for at least that length of time. In the present eight-year panel, 23 firms included a CSCO in their TMT at least once.

Firm size. For present purposes, the firm size was included as a moderator. Using a common operational definition, this variable was measured as the natural logarithm of total firm sales in millions of dollars in the year prior to the focal year (Steven *et al.*, 2014).

3.5 Control variables

TMT size. As emerging positions like CSCO are more likely to be found in large TMTs (Roh *et al.*, 2016), the study controlled for TMT size. In addition, as larger boards may require more time and effort to reach consensus on strategic decisions (Cheng, 2008), which affects the ease of implementation of recall prevention or reduction measures, TMT size was operationalised as a number of directors in the given firm-year (as per BoardEx).

COO presence (COO). The presence of a chief operating officer (COO) is another TMT characteristic that may affect the influence of CSCOs (Roh *et al.*, 2016). COOs are typically mandated to coordinate manufacturing activities, which may enhance quality performance but may also conflict with some aspects of CSCO decision-making. Measured as a dichotomous outcome, *COO presence* was assigned a value of "1" if a COO was present for a given firm-year; otherwise, it was coded "0". As in the case of *CSCO presence*, a COO was defined as present if the position was occupied for at least six months. The COO job title was identified in BoardEx:

- by the job title Chief Operating Officer, Chief Operations Officer or COO; and
- if the job title containing the term "ope", "ops" or "operations", accompanied by "corporate", "chief", "executive vice president", "executive VP", "group director", "group vice president" or "group VP".

Recall experience. In the relevant literature, *recall experience* is frequently used as a control variable (Steven *et al.*, 2014; Wowak *et al.*, 2015; Hall and Johnson-Hall, 2017; Ball *et al.*, 2018). The likelihood of future recalls may be associated with previous experience of recalls (Haunschild and Rhee, 2004; Thirumalai and Sinha, 2011), which may, in turn, influence the appointment of a CSCO to improve quality performance. For present purposes, *recall experience* was measured as the sum of all recalls in the previous four years for a given firm-year; for example, prior recalls for 2010 included the years 2009 to 2006.

Research and development intensity (R&D). Incidence of recalls may be associated with a firm's level of involvement in R&D activities (Thirumalai and Sinha, 2011), which is widely used as a control variable in the relevant literature. For present purposes, the variable was measured as the ratio of R&D expenses to sales in the year prior to the focal year. Given a large number of missing values (160 observations) in the sample, we used a multiple imputation procedure (Fichman and Cummings, 2003), which obtains multiple estimates for the missing values from sampling inferences based on the distribution of the observed data (Rubin, 1976). These estimates are then averaged for use in the analysis (Schenker and Taylor, 1996).

Capital intensity (CAP). To detect quality problems, capital investment is needed – for example, to upgrade IT tools for enhanced supply chain visibility (Steven *et al.*, 2014), making it easier to detect quality problems before products reach consumers. *CAP* was measured as the ratio of capital expenditures to sales in the year prior to the focal year.

Return on assets (ROA). According to previous studies (Wowak *et al.*, 2015; Hall and Johnson-Hall, 2017; Ball *et al.*, 2018), product recalls may be linked to ROA for two reasons: if firms' efforts to improve ROA involve cost-cutting activities that harm product quality or if current performance level influences decision-making and strategic direction regarding investment in quality management (Audia and Greve, 2006). Here, ROA was measured as the ratio of net income to total assets in the year prior to the focal year.

Year indicators and industry effects. When analysing longitudinal data, it is important to account for contemporaneous correlation (Certo and Semadeni, 2006). For that reason, *year indicators* were included in the models. As the sample included firms from different industries, differing technologies and production processes may affect the incidence of recalls (Steven *et al.*, 2014). To capture any such characteristics, we included industry-specific indicator variables based on three-digit NAICS codes (22 industrial codes in total). Industry- and year-specific effects were included but are not shown in the regression tables.

3.6 Empirical modelling

To test the hypotheses, two models were estimated.

$$
\begin{aligned}
\textbf{Model 1: } R_{ikt} = {}& \beta_0 + \beta_1 CSCO_{ikt} + \beta_2 TMTSize_{ikt} \\
& + \beta_3 COO_{ikt} + \beta_4 RecallExperience_{ikt} \\
& + \beta_5 FirmSize_{ikt-1} + \beta_6 R\&D_{ikt-1} \\
& + \beta_7 CAP_{ikt-1} + \beta_8 ROA_{ikt-1} \\
& + Industryeffects_k + Yeareffects_t + \varepsilon_{1ikt}
\end{aligned}
$$

$$
\begin{aligned}
\textbf{Model 2: } R_{ikt} = {}& \gamma_0 + \gamma_1 CSCO_{ikt} + \gamma_2 TMTSize_{ikt} + \gamma_3 COO_{ikt} \\
& + \gamma_4 RecallExperience_{ikt} + \gamma_5 FirmSize_{ikt-1} \\
& + \gamma_6 R\&D_{ikt-1} + \gamma_7 CAP_{ikt-1} + \gamma_8 ROA_{ikt-1} \\
& + \gamma_9 CSCO_{ikt}{}^* FirmSize_{ikt-1} + Industryeffects_k \\
& + Yeareffects_t + \varepsilon_{2ikt}
\end{aligned}
$$

R_{ikt} denotes the number of recalls for firm i (i = 1 to 126) in industry k (k = 1 to 22) in year t (t = 2010 to 2017); ε_{1it} and ε_{2it} are the respective error terms for Models 1 and 2.

The dependent variable was an over-dispersed count variable. Based on the recall literature, the two hypotheses were tested using a negative binomial model (Haunschild and Rhee, 2004; Steven *et al.*, 2014; Thirumalai and Sinha, 2011; Wowak *et al.*, 2015; Shah *et al.*, 2017; Ball *et al.*, 2018). The literature refers to four types of negative binomial model: fixed effects (FE), random effects (RE), mixed-effects incorporating nested effects and the generalised estimation equation (GEE) method. The advantage of FE models is that they correct for omitted variable biases due to unobservable factors that do not change over time; their disadvantage is that observations showing no variance in the dependent or independent variables are automatically excluded from the analysis (Greene, 2012). As many observations in the present study exhibited no variation in the independent variable (as most firms had no CSCO within the sampled timeframe), RE modelling was used (For a more extensive discussion, Sine *et al.*, 2003; Shah *et al.*, 2017; Ball *et al.*, 2018). A Hausman specification test was performed to test the null hypothesis that individual effects are not correlated with the independent variables (Greene, 2012). As the null hypothesis was not rejected ($p < 0.05$), the results indicate a preference for RE rather than FE modelling.

Two recent studies have advocated the use of GEE rather than RE modelling (Wowak *et al.*, 2015; Shah *et al.*, 2017). The advantage of GEE models is that they do not assume a normal distribution of the dependent variable or case independence. However, both of those studies were conducted within a single industry sector (pharmaceutical and automotive, respectively). As the present study encompasses multiple industries, firms were nested within sectors. This implies a correlation amongst observations within the same sector, as firms are likely to resemble those in the same sector more than those in other sectors (Rabe-Hesketh and Skrondal, 2012) – that is, there are industry-level random effects. For example, *CSCO presence* varies across industries because the importance assigned to supply chain management differs (Wagner and Kemmerling, 2014). Additionally, Steven *et al.* (2014) reported different levels of recalls in different industries. Neglecting intra-cluster correlations of this kind can distort estimates and standard errors (Cameron and Trivedi, 2005).

Based on the above, a mixed-effects negative binomial regression was used to model intra-cluster correlation and to account for within-firm and between-firm variations (Results of GEE, FE and RE robustness checks are reported in Tables A1 and A2 in the Appendix). In the present case, firms were nested within industries (k) and shared common industry-level random effects. The results of a likelihood ratio test indicated sufficient variance between firms to favour a mixed-effects negative binomial regression rather than a negative binomial regression without random effects (Wooldridge, 2002). All analyses were performed using STATA version 15.1.

4. Results

4.1 Descriptives and correlations

The descriptive statistics in Table 1 show that the mean of recalls in the present sample is 0.481, which is considerably higher than the mean of 0.22 reported by Steven *et al.* (2014), providing further evidence of the increasing incidence of recalls (Steven *et al.'s* (2014) study investigated the period 2010-2012). Mean *CSCO presence* of 0.086 and mean *COO presence* of 0.4 are not dissimilar to the values reported by Roh *et al.* (2016) (0.07 and 0.33, respectively).

The Pearson correlations in Table 2 indicate that *CSCO presence, COO presence, R&D intensity, Capital intensity* and *ROA* are negatively correlated with the incidence of recalls while *TMT size, recall the experience* and *firm size* exhibit a positive correlation. The strongest correlation is between recalls and *recall experience*, which aligns with the findings of Ball *et al.* (2018). Amongst the independent variables, the largest correlation is between *firm size* and *TMT size* (0.320). Variance inflation factors (VIFs) were calculated to eliminate concerns about multicollinearity; as the mean VIF is 1.19 and VIF for each model is below 2, multi-collinearity effects are limited (Kutner *et al.*, 2005).

4.2 Hypothesis testing

Results for the mixed-effects negative binomial models are summarised in Table 3. Model 1 introduces the control variables;

Table 1 Descriptives

No.	Variable	Mean	SD	Min	Max
1	Recalls	0.481	1.097	0	14
2	CSCO	0.086	–	–	–
3	TMT size	10.688	2.789	4	26
4	COO	0.4	–	–	–
5	Recall experience	2.994	6.529	0	73
6	Firm size (mil. US$)	22,691	46,734	51	483,521
7	R&D	0.032	0.036	0	0.254
8	CAP	0.035	0.026	0.004	0.313
9	ROA	0.060	0.071	−0.608	0.507

Note: n = 885

Table 2 Correlations[a]

No.	Variable	1	2	3	4	5	6	7	8	9
1	Recalls	1								
2	CSCO	−0.046	1							
3	TMT size	0.029	0.027	1						
4	COO	−0.041	0.021	−0.057	1					
5	Recall experience	0.491*	0.128*	0.026	0.008	1				
6	Firm size (mil. US$)	0.123*	0.053	0.327*	−0.098*	0.328*	1			
7	R&D	−0.068*	−0.188*	0.137*	−0.133*	−0.168*	0.048	1		
8	CAP	0.003	−0.014	0.058	0.008	−0.057	0.119*	0.221*	1	
9	ROA	−0.023	0.049	−0.005	0.022	−0.015	−0.029	−0.089*	−0.014	1

Notes: $n = 885$; *p-value < 0.05; [a]Pearson's correlations

Table 3 Mixed-effects regression results

|	Dependent variable		
	Model 1 recalls	Model 2 recalls	Model 3 recalls
Independent variables	Coefficient (standard error)	Coefficient (standard error)	Coefficient (standard error)
CSCO	–	−0.756** (0.280)	3.570* (1.371)
TMT size	0.004 (0.009)	0.011 (0.029)	0.022 (0.029)
COO	−0.153 (0.129)	−0.158 (0.129)	−0.157 (0.129)
Recall experience	0.052** (0.009)	0.052** (0.009)	0.059** (0.009)
Firm size	0.087 (0.050)	0.084 (0.050)	0.087 (0.050)
R&D	−2.470 (2.555)	−3.200 (2.583)	−3.070 (2.581)
CAP	2.372 (2.429)	2.457 (2.340)	1.922 (2.439)
ROA	0.158 (0.912)	0.240 (0.902)	0.222 (0.915)
CSCO*Firm size	–	–	−0.462** (0.147)
Intercept	−1.555** (0.424)	−1.578* (0.423)	−1.797** (0.430)
# of observations	885	885	885
Wald χ^2	96.83	104.12	104.09
Probability ($>\chi^2$)	0.00	0.00	0.00

Notes: Year-specific and industry-specific effects included, not shown. *p-value < 0.05, **p-value < 0.01

as in previous studies, *recall experience* ($p < 0.01$) is positively associated with recalls. Model 2 adds the effect of *CSCO presence*. *H1* predicted a negative relationship between *CSCO presence* and incidence of recalls and this is supported by the results ($\beta_1 = -0.756$; $p < 0.01$). Model 3 introduces the interaction effect to test *H2*, which posited that the negative relationship between *CSCO presence* and product recalls would be stronger in larger firms. As the interaction term *CSCO*firm size* is significant and negative ($\gamma_9 = -0.462$, $p < 0.01$), the hypothesis is not rejected. To assist interpretation, the moderation effect was plotted. As shown in Figure 2, larger firms (one standard deviation above the mean size) with a CSCO in the TMT reported fewer recalls than smaller firms. The overall goodness of fit (Wald Chi^2) was significant for all three models, with values of 96.83, 104.12 and 104.09, respectively.

4.3 Robustness checks

Amongst several robustness checks, RE, FE and GEE negative binomial models were used to check the consistency of estimates across the different approaches. The corresponding results for each model can be found in the Appendix (Table A1: main effect; Table A2: interaction effect). *CSCO presence* was negative and significant for all models, lending robust support

Figure 2 Interaction effect of CSCO presence and firm size on the incidence of recalls
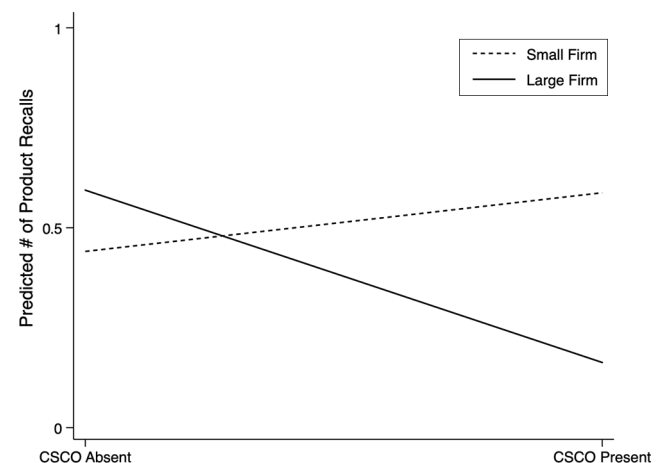
to *H1*. The *CSCO*Firm size* interaction was negative and significant in the RE and GEE models but not in FE ($p < 0.08$). Following Ball *et al.* (2018), we also addressed concerns regarding serial correlation in the *recall experience* control

variable. Repeating the analysis without *recall experience* yielded the same results (available on request).

As it is reasonable to suppose that the incidence of product recalls might prompt a serious review of internal quality management and leadership practices, a reverse causality test was also performed. In particular, the appointment of CSCOs might follow the deterioration of quality performance. To test the extent to which the results were affected by reverse causality, the subsequent year's *CSCO presence* ($CSCO_{t+1}$) was regressed on all of the control variables. Three logit models (RE, FE and mixed) and two probit models (RE and mixed) failed to identify any significant effect of *recall experience* on *CSCO presence*. While reverse causality can never be definitively ruled out in panel data models (Leszczensky and Wolbring, 2019), our results replicate Ball *et al.'s* (2018) failure to find a significant association between recall experience and the focal explanatory variables, so alleviating concerns about reverse causality. The results of this analysis can be found in Appendix Table A3.

As the dependent variable was truncated, the analysis was rerun using a Tobit regression to check whether the results aligned with a censored data model (Greene, 2012). Goodness-of-fit values (Wald Chi^2), the *CSCO presence* coefficient and the interaction coefficient (*CSCO**firm size) were consistent with the mixed-effects negative binomial estimation. The results can be found in Appendix Table A4.

A final robustness check assessed whether the effect of *CSCO presence* on the incidence of recalls persists over time. As some strategic initiatives that affect quality performance have lasting effects (Wowak *et al.*, 2013; Wowak and Boone, 2015) or a long discovery-to-recall time (Ni and Huang, 2017), *CSCO presence* was lagged by one year and we found support for the lasting effect of *CSCO presence* ($p < 0.05$). Details of the analysis can be found in Appendix Table A5.

4.4 Post hoc analysis: Insider versus outsider chief supply chain officers

When appointing executives to the TMT, firms may opt for an insider (promoted from within) or an outsider (not previously employed at the firm). This is an important decision, as both options have benefits and disadvantages and the fact that the stock market reacts differently to the appointment of outsider CSCOs corroborates this conjecture (Hendricks *et al.*, 2015). For that reason, a further analysis assessed the extent to which appointing an insider or outsider CSCO affects the incidence of product recalls.

For the purpose of this post hoc analysis, *CSCO presence* was segmented into two variables: *insider* and *outsider*. Both were measured as dichotomous outcomes. A CSCO was classified as an *insider* if already used by that firm, and as an *outsider* if hired externally. Based on the information retrieved from the BoardEx sub-regional data set (individual employment history), 16 firms were found to have appointed an *insider* as CSCO at least once while 11 firms had appointed an *outsider* at least once over the relevant eight-year period.

The results in Table 4 (second column) show that both *insider* and *outsider* coefficients are significantly negative ($\beta_{insider} = -0.707$ ($p < 0.05$); $\beta_{outsider} = -0.839$ ($p < 0.05$), respectively). The Wald Chi^2 test shows that $\beta_{insider}$ and $\beta_{outsider}$ are not significantly different at the 5% significance level (Greene, 2012). The moderating effect of *firm size* on quality performance (third column) is only significant for insider CSCOs ($\beta_{insider*size} = -0.519$, $p < 0.01$), suggesting that larger firms benefit from CSCOs with high levels of firm-specific supply chain knowledge (Wowak *et al.*, 2013) in a way that smaller firms do not. Compared with outsiders, insider CSCOs may have had more opportunities to acquire knowledge about consumer requirements, organisational processes and supply networks (Harris and Helfat, 1997; Geletkanycz *et al.*, 2001). Additionally, insiders are more likely to possess high levels of firm-specific social capital (Fang *et al.*, 2011), which may prove valuable when developing and

Table 4 Mixed-effects regression results: post hoc

	Dependent variable		
Independent variables	Coefficient (standard error) **Model 4 recalls**	Coefficient (standard error) **Model 5 recalls**	Coefficient (standard error) **Model 6 recalls**
Insider	–	−0.707* (0.345)	4.294** (1.573)
Outsider	–	−0.839* (0.454)	2.865 (3.308)
TMT size	0.004 (0.029)	0.011 (0.029)	0.022 (0.029)
COO	−0.153 (0.129)	−0.156 (0.128)	−0.154 (0.129)
Recall experience	0.052** (0.009)	0.052** (0.009)	0.059** (0.009)
Firm size	0.087 (0.050)	0.084 (0.050)	0.086 (0.050)
R&D	−2.470 (2.555)	−3.193 (2.582)	−3.048 (2.573)
CAP	2.372 (2.429)	2.462 (1.287)	1.953 (2.437)
ROA	0.158 (0.912)	0.220 (0.906)	0.150 (0.918)
Insider*firm size	–	–	−0.519** (0.164)
Outsider*firm size	–	–	−0.421 (0.382)
Intercept	−1.555** (0.424)	−1.573** (0.423)	−1.799** (0.429)
# of observations	885	885	885
Wald χ^2	96.83	104.00	104.94
Probability (>χ^2)	0.00	0.00	0.00

Notes: Year-specific and industry-specific effects included, not shown. *p-value < 0.05, **p-value < 0.01

implementing quality enhancement initiatives in firms embedded in more complex and unique supply chains (Cao and Zhang, 2011).

5. Discussion

As CSCOs become increasingly common in TMTs, a growing number of empirical studies have examined the effects of CSCOs on financial (Wagner and Kemmerling, 2014; Roh *et al.*, 2016) and stock market performance (Hendricks *et al.*, 2015). Although valuable, these studies have not considered the operational dimensions of firm performance. In recent years, too, there has been growing interest in identifying firm characteristics that seem likely to influence the frequency of recalls (Thirumalai and Sinha, 2011; Steven *et al.*, 2014; Chiarini, 2015; Shah *et al.*, 2017). However, these studies have not taken account of the presence of supply chain management executives in the TMT. This is a significant omission because recalls are a fundamental issue for contemporary supply chains, and consumers, firms, regulators and policymakers would benefit from a fuller understanding of their multifaceted causes. Responding to the call to clarify the nonoperational antecedents of product recalls (Wowak and Boone, 2015), the present study illuminates the relevance of CSCO positions in this regard.

5.1 Theoretical implications
The present findings confirm that executives with the direct command of supply chain operations can play an important role in preventing product recalls, especially in larger firms. In so doing, these findings clarify the relationship between quality performance and corporate governance. Existing research suggests that shareholder pressures not only fail to penalise executives who make recall-generating decisions but may actually induce such decisions (Bromiley and Marcus, 1989). Additionally, the pursuit of short-term stock market gains may incentivise cuts in quality-enhancing expenditure, so increasing the incidence of product recalls (Wowak *et al.*, 2015). The present findings corroborate existing evidence of the potentially profound effect of decisions at the highest level on quality processes and performance. However, like Kashmiri and Brower (2016), these findings also show that top-level decisions can prevent external quality failures. In particular, the presence of a CSCO in the TMT makes it less likely that decisions will neglect quality risks or that strategic resource allocation will misjudge the threat of systematic product failures. This finding reinvigorates classical arguments regarding the importance in manufacturing firms of operations leadership (Skinner, 1969; Wheelwright, 1984) and quality leadership (Deming, 1986; Juran, 1999) and extends the notion to the dispersed and complex context of contemporary supply chains. In such settings, effective quality management requires both supply chain expertise and control based on effective governance structures. Moreover, this finding validates the increasingly popular notion that CSCOs are amongst the most powerful executives in the firm's upper echelons (Morris, 2015; Thalbauer, 2016).

The critical role of CSCO quality leadership in the context of dispersed and complex supply chains is further substantiated by its higher impact on the incidence of product recalls in larger firms. This suggests that appropriate integrative capabilities at the TMT level can help to prevent serious quality issues in culturally or geographically dispersed supply chains involving high levels of functional segmentation. This insight augments existing knowledge of the relationship between firm performance and supply chain management capabilities (Ellinger *et al.*, 2011; Wowak *et al.*, 2013; Derwik and Hellstrom, 2017) in contemporary competitive environments.

The present findings also serve to clarify the CSCO-performance link. Previous evidence regarding the influence of top supply chain executives on firm performance is inconclusive. While firms with high levels of supply chain competency have been shown to outperform their competitors (Ellinger *et al.*, 2011), there is also evidence that the presence of CSCOs in TMTs does not always translate into stronger financial performance (Wagner and Kemmerling, 2014; Roh *et al.*, 2016). The present findings suggest that this inconsistency may be explained by the limitations of metrics like ROA or operating profits when assessing strategic supply chain decisions that need time to take effect, where the long-term benefits may sometimes be hard to measure. By investigating the incidence of infrequent operational disruptions that nevertheless have damaging reputational and liability consequences, the present study takes fuller account of the CSCO's influence on the TMT and on performance. By showing that the presence of a CSCO in the TMT can improve a firm's ability to bring defect-free products to market, the findings validate the theoretical argument advanced here, as well as the expectations of shareholders when operations and supply chain management experts are appointed to the TMT (Hendricks *et al.*, 2015).

Finally, the post hoc analysis indicates that only CSCOs recruited from the internal talent pool are effective in reducing the incidence of recalls in large firms. Although further investigation is needed, this finding suggests that firm-specific knowledge of customer requirements, internal processes and supplier relationships is critical for the development of integrated quality management capabilities (Harris and Helfat, 1997; Geletkanycz *et al.*, 2001). This also suggests that occupying a central position in internal social networks facilitates the implementation of a supply chain-wide vision of quality excellence (Ocasio, 1999; Fang *et al.*, 2011).

5.2 Practical implications
The present findings indicate that corporate governance policies that assign supply chain specialists to the TMT help to reduce the frequency of damaging product recalls. In the present sample, having a CSCO in the TMT was associated with a 53% decrease in product recalls in a firm-year, corresponding to a reduction of about two recalls per firm across the eight-year panel (Beta coefficients for negative binomial models can be interpreted after exponentiation (Wooldridge, 2002); Ball *et al.* (2018) for step-by-step application). One immediate practical implication is that consolidated supervision at the highest decision-making level facilitates the prevention of catastrophic quality failures in contemporary extended supply chains. In the consumer product sector, this is an important consideration when designing TMTs and specifying their composition. Based on these findings, it seems clear that shareholders, boards of

directors and CEOs of firms embedded in complex and idiosyncratic supply chains should centralise authority and coordination in respect of inbound, internal and outbound quality-related processes in the TMT.

The post hoc analysis highlights the role of firm-specific experience and a network of contacts in maintaining quality standards across supply chains and preventing defective products from reaching consumers. This has practical relevance for CEOs when recruiting a CSCO, especially in large firms embedded in multi-tier supply chains. Given the relative novelty of this position and its enterprise-wide relevance, firms should seek to promote someone from the internal talent pool, as CSCOs with first-hand knowledge of organisational processes and resources may be more effective in identifying quality risks and implementing effective mitigating measures.

6. Conclusion, limitations and future research

Addressing the increased interest in the antecedents of product recalls, the present study links this issue to the emerging literature on the rise and role of CSCOs. Despite increasing research interest in firm characteristics that affect recall frequency, no previous study has taken account of CSCO presence in the TMT. Regarding the influence of supply chain management executives in addressing the causes of recalls, the present findings suggest that firms with CSCOs issue fewer recall, confirming that corporate governance policies can impact positively on quality excellence in contemporary supply chains. The findings indicate that this effect is more pronounced in firms that operate in more extended and geographically dispersed supply chains, and the study explores which CSCO profiles may be more effective in such settings. In so doing, the study links nonoperational antecedents of product recalls to the influence of supply chain management executives on firm performance.

The present study has limitations, nevertheless. In particular, the research design could not disclose the mechanisms underlying CSCO's influence on supply chain quality performance – that is, how CSCO participation in strategic decision-making affects the causes of recalls. Future studies should explore this mechanism by investigating firm-level quality management capabilities and how these relate to TMT characteristics. Similarly, the present approach could not determine whether and under what circumstances CSCOs can more effectively mitigate quality risks in inbound, internal and outbound processes. One immediate goal for future research should be to identify the source of recall-inducing defects and to link this to the CSCO's activities.

A further limitation of the present study is that the data were collected from the CPSC, which only has jurisdiction over consumer products. The relationship between CSCO presence and recall incidence may differ in firms regulated by other agencies such as the National Highway Traffic Safety Administration, the Food Safety and Inspection Service, the Food and Drug Administration and the Environmental Protection Agency. Future studies should also examine the role of supply chain executives in sectors where product recalls are of critical importance to the public, as for instance in the automotive and pharmaceutical industries.

As we only observed firms that issued at least one recall within the selected period, we were unable to theorise about the likelihood of recall occurrence and our analysis was confined to firms that have experienced at least one major external quality failure. For that reason, our findings cannot reliably be generalised to firms that achieve very high levels of quality and have no need to recall their products. Future studies should deploy sample matching techniques such as the propensity score method (Li, 2013) to study the effects of CSCO presence in firms with no issued recalls.

A further limitation is that data collection was confined to publicly listed firms. CSCO presence and effectiveness may differ in private firms because the lack of shareholder pressure means that the risk of product recalls may be more easily tolerated, perhaps, altering the relationship between supply chain executives and quality performance.

Moreover, in exploring whether CSCOs have any beneficial effect on the recall management process, it would be useful to determine the extent to which CSCO presence influences the time that elapses between initial reporting of a suspected defect and announcement of a recall. Finally, the post hoc investigation suggests that understanding the individual characteristics of CSCOs can provide further insights into the recall phenomenon and future studies should assess how CSCO gender, experience and education (amongst other factors) influence the prevention and management of product recalls.

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Appendix

Table A1 Robustness main effect: alternative negative binomial models

Independent variables	Dependent variable		
	Model A1a recalls [random effects][a] Coefficient (standard error)	Model A1b recalls [fixed effects][b] Coefficient (standard error)	Model A1c recalls [PA – GEE][a],[†] Coefficient (standard error)
CSCO	−0.936** (0.252)	−0.999** (0.301)	−0.837** (0.302)
TMT size	0.028 (0.029)	0.117* (0.051)	0.027 (0.032)
COO	−0.190 (0.124)	−0.457* (0.206)	−0.161 (0.137)
Recall experience	0.039** (0.006)	0.017 (0.012)	0.052** (0.009)
Firm size	0.096* (0.048)	−0.191 (0.159)	0.092 (0.051)
R&D	−3.483 (2.697)	2.462 (5.989)	−3.565 (2.775)
CAP	1.741 (2.338)	5.650 (4.261)	2.626 (2.510)
ROA	0.429 (0.856)	−1.617 (1.348)	0.805 (0.976)
Intercept	−0.664 (0.798)	1.440 (1.394)	−2.336** (0.753)
# of observations	885	885	885
Wald χ^2	364.18	74.72	219.82
Probability ($>\chi^2$)	0.00	0.00	0.00

Notes: *p-value < 0.05, **p-value < 0.01. [a]Year-specific and industry-specific effects included, not shown [b]Year-specific effects included, not shown. [†]Results hold when robust standard errors are used

Table A2 Robustness interaction effect: alternative negative binomial models

Independent variables	Dependent variable		
	Model A2a recalls [random effects][a] Coefficient (standard error)	Model A2b recalls [fixed effects][b] Coefficient (standard error)	Model A2c recalls [PA – GEE][a],[†] Coefficient (standard error)
CSCO	2.251 (1.376)	3.154 (2.254)	3.718* (1.593)
TMT size	0.036 (0.029)	0.117* (0.051)	0.039 (0.032)
COO	−0.182 (0.124)	−0.447* (0.192)	−0.154 (0.137)
Recall experience	0.042** (0.006)	0.016 (0.014)	0.060** (0.009)
Firm size	0.099* (0.049)	−0.213 (0.149)	0.092 (0.051)
R&D	−3.608 (2.719)	2.608 (5.995)	−3.651 (2.786)
CAP	1.404 (2.372)	5.388 (4.260)	2.069 (2.559)
ROA	0.422 (0.863)	−1.638 (1.349)	0.772 (0.985)
CSCO*firm size	−0.322* (0.143)	−0.440 (0.246)	−0.494** (0.173)
Intercept	−0.766 (0.809)	1.632 (1.342)	−2.479** (0.758)
# of observations	885	885	885
Wald Chi^2	368.97	72.43	234.66
Probability ($>$Chi^2)	0.00	0.00	0.00

Notes: *p-value < 0.05, **p-value < 0.01. [a]Year-specific and industry-specific effects included, not shown. [b]Year-specific effects included, not shown. [†]Results hold when robust standard errors are used

Table A3 Robustness: reverse causality

Independent variables	Model A3a CSCO$_{t+1}$ [mixed logit][b,d] Coefficient (standard error)	Dependent variable Model A3b CSCO$_{t+1}$ [RE logit][b,d] Coefficient (standard error)	Model A3c CSCO$_{t+1}$ [FE logit][c] Coefficient (standard error)
Recall experience[a]	0.003 (0.024)	−0.033 (0.014)	−0.036 (0.036)
TMT size	0.168* (0.075)	0.472* (0.189)	0.564* (0.262)
COO	−0.523 (0.309)	−1.013 (0.567)	−0.896 (0.595)
Firm size	−0.020 (0.138)	0.099 (0.420)	0.207 (0.868)
R&D	−12.184 (7.390)	−0.635 (13.691)	56.371 (38.803)
CAP	7.042 (7.990)	−2.438 (17.157)	4.414 (20.548)
ROA	0.554 (2.071)	1.799 (3.847)	4.198 (4.238)
Intercept	5.688** (1.536)	−8.894 (4.704)	–
# of observations		561	
Wald χ^2 or χ^2	27.25	31.74	31.14
Probability (>χ^2)	0.02	0.20	0.01

Notes: *p-value < 0.05, **p-value < 0.01. [a]Recall experience is the sum of all four years prior to $t+1$. [b]Year-specific and industry-specific effects included, not shown. [c]Year-specific effects included, not shown. [d]The results of recall experience and TMT size hold when probabilistic regression (probit) is used for estimation

Table A4 Robustness: Tobit regression

Independent variables	Model A4a recalls Coefficient (standard error)	Dependent variable Model A4b recalls Coefficient (standard error)	Model A4c recalls Coefficient (standard error)
CSCO	–	−0.469** (0.124)	2.737** (0.758)
TMT size	0.004 (0.015)	0.010 (0.015)	0.013 (0.015)
COO	−0.093 (0.069)	−0.107 (0.068)	−0.089 (0.068)
Recall experience	0.077** (0.006)	0.076** (0.006)	0.078** (0.006)
Firm size	0.026 (0.026)	0.025 (0.026)	0.030 (0.026)
R&D	−0.534 (1.109)	−0.849 (1.104)	−0.883 (1.092)
CAP	1.737 (1.297)	1.833 (1.287)	1.401 (1.278)
ROA	0.295 (0.470)	0.314 (0.466)	0.246 (0.462)
CSCO*firm size	–	–	−0.352** (0.082)
Intercept	0.147 (0.352)	0.185 (0.350)	0.148 (0.346)
# of observations	885	885	885
# of industries	22	22	22
Wald χ^2	373.51	393.81	420.36
Probability (>χ^2)	0.00	0.00	0.00

Notes: Year-specific and industry-specific effects included, not shown. **p-value < 0.01

Table A5 Robustness: lagged CSCO presence mixed-effects regression results

| Independent variables | Dependent variable | | |
	Model A5a recalls Coefficient (standard error)	Model A5b recalls Coefficient (standard error)	Model A5c recalls Coefficient (standard error)
$CSCO_{t-1}$	–	−0.679* (0.305)	3.193* (1.435)
TMT size	0.004 (0.009)	0.009 (0.029)	0.019 (0.029)
COO	−0.153 (0.129)	−0.152 (0.129)	−0.160 (0.129)
Recall experience	0.052** (0.009)	0.052** (0.009)	0.058** (0.009)
Firm size	0.087 (0.050)	0.084 (0.050)	0.086 (0.050)
R&D	−2.470 (2.555)	−3.001 (2.581)	−2.986 (2.577)
CAP	2.372 (2.429)	2.472 (2.404)	2.130 (2.435)
ROA	0.158 (0.912)	0.202 (0.908)	0.235 (0.920)
$CSCO_{t-1}$*firm size	–	–	−0.412** (0.153)
Intercept	−1.555** (0.424)	−1.566* (0.424)	−1.754** (0.431)
# of observations	885	885	885
Wald χ^2	96.83	101.85	102.03
Probability ($>\chi^2$)	0.00	0.00	0.00

Notes: Year-specific and industry-specific effects included, not shown. *p-value < 0.05, **p-value < 0.01

Corresponding author

Diogo Cotta can be contacted at: d.cotta@maastrichtuniversity.nl